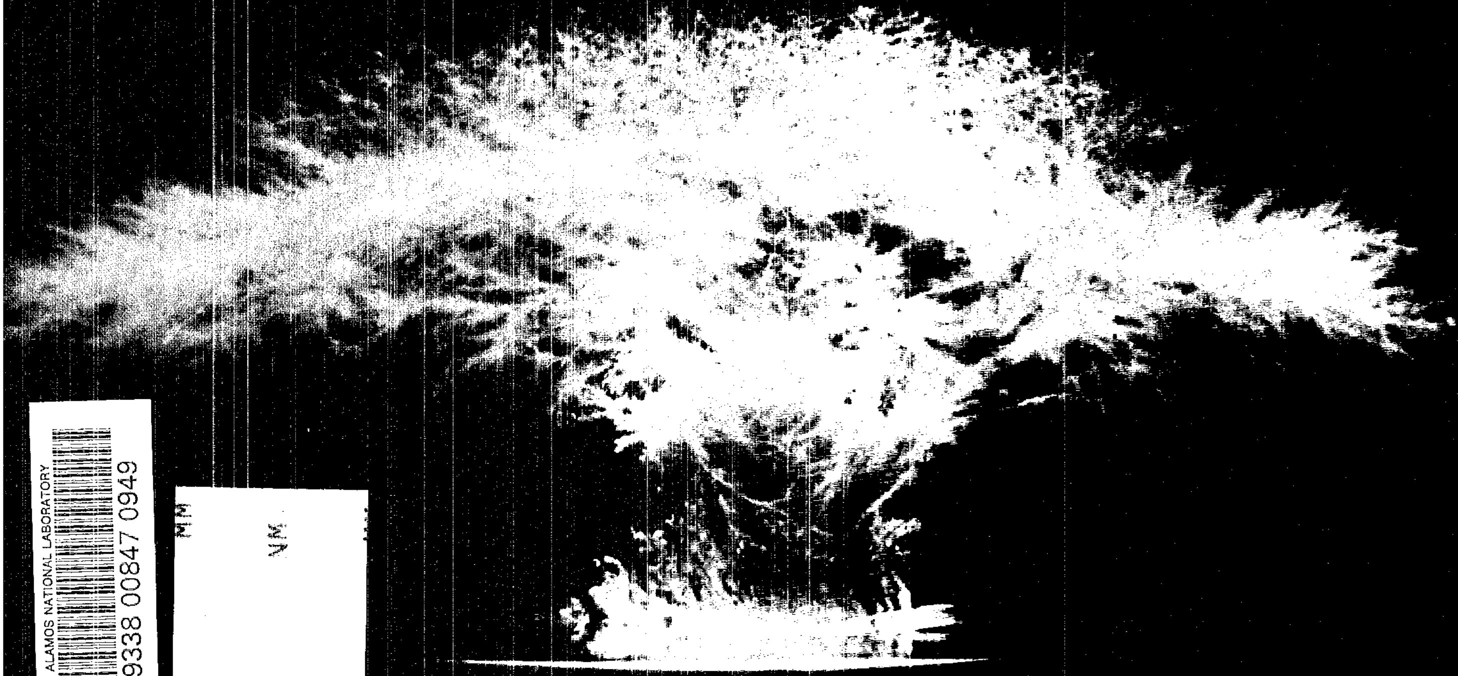
the Atom

Los Alamos Scientific Laboratory

July-August 1975



PARTICLES: a special section

Volume 12 Number 4
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Published bimonthly by the University of California, Los Alamos Scientific Laboratory, Office of Public Information, TA-3, West Jemez Road, Los Alamos, New Mexico 87545. Address mail to P.O. Box 1663, Los Alamos, New Mexico 87545. Second Class Postage Paid at Los Alamos, N.M.

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Office: D-442-B Administration Building. Telephone: 667-6102. Printed by the University of New Mexico Printing Plant, Albuquerque.

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COVER

Is the enigmatic image on the front cover that of some tree, not of this world, but as might be seen in some troubled dream? Is it of a nuclear explosion as recorded on some special film? Is it of some newly discovered microscopic fungus?

The photo, taken by Henry Ortega, ISD-7, is of none of these. Instead, the photo is an enlargement of the fracturing that occurs within small lucite pucks when exposed to an intense electron beam. The electron beam, in this case, is one generated by a new linear accelerator now in use in the Physics Building as part of a new system for generating soft x rays by colliding electron and photon beams.

The extent to which the particles penetrate the puck is shown by the fracture pattern, providing a crude but useful measurement of the beam's energy. The characteristics of the spot where the beam entered the puck serves as a guide to focusing adjustments. For more on this new system, see the story beginning on page 11.

Since the image within the puck was created by particles, it seemed an appropriate one for the front cover. Aside from its pictorial appeal, it calls attention to the special section on particles beginning on the opposite page.

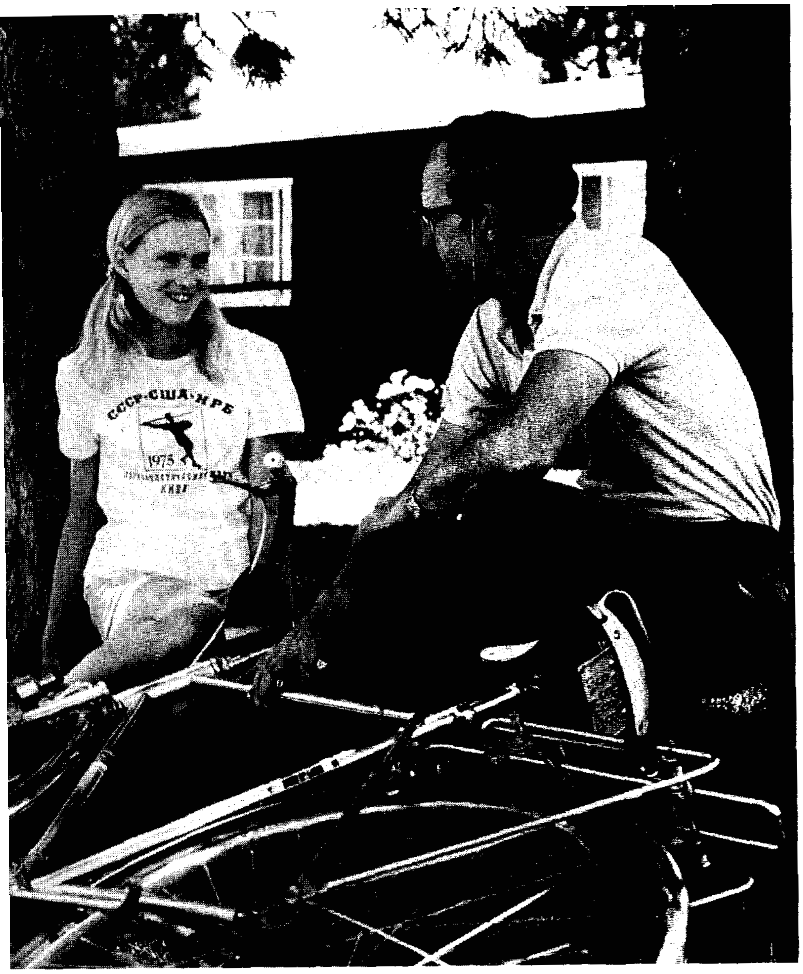
Among Our Guests

Flying into Los Alamos on May 29, was U.S. Senator Pete V. Domenici of New Mexico, here being welcomed by Duncan MacDougall, associate director for weapons. Senator Domenici spoke at a colloquium on "The Importance of a Balanced Energy Development Program."

On July 24, Robert Seamans, Administrator of the U.S. Energy Research and Development Administration, right, visited LASL for the first time for briefings in the Green Room on Laboratory operations in general and energy programs in particular. He is shown with Duncan MacDougall, associate director for weapons, left, and Harold Agnew, Director, center.

U.S. Treasurer Francine Neff visited LASL on June 9 for briefings and tours of Laboratory sites. Here she talks with Charles Browne, assistant director for administration.

From the Atomic Weapons Research Establishment at Aldermaston, England, on June 19-20 came, left to right, John Hallam, Kenneth Stewart, and John Marriage to discuss effects of nuclear-weapon detonations. Here they meet with George Best, second from right, and Thomas Dowler, right, both ADWP-2.

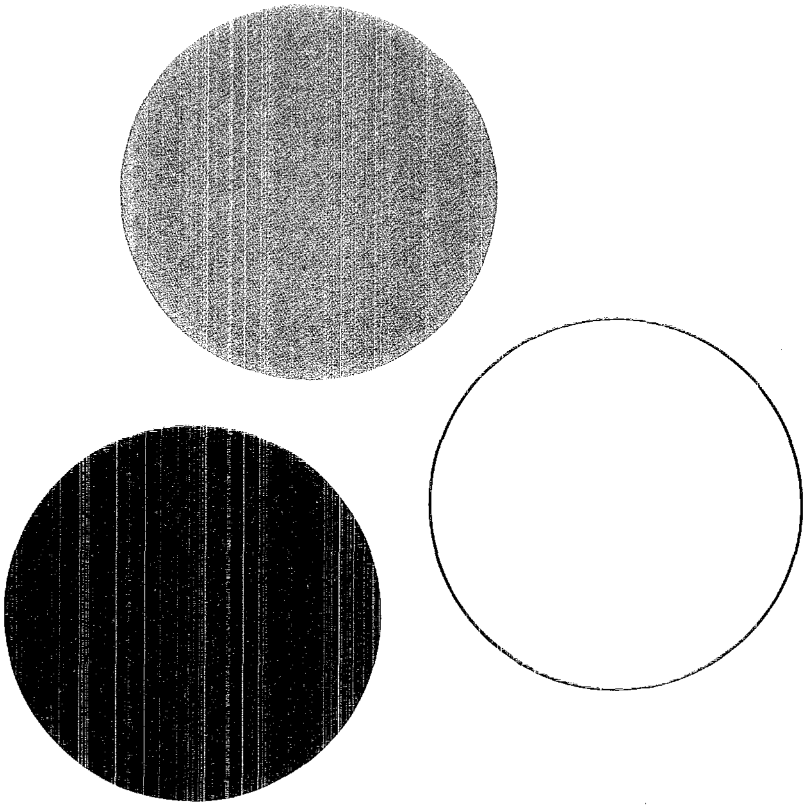


The back cover of **The Atom** becomes a sports page for this issue in recognition of 2 recent athletic achievements by LASL families.

Lynn Bjorklund, 18, won the women's 3000-meter event at the AAU Nationals in White Plains, N.Y., in June, went on to place third in the same event at the U.S.-U.S.S.R.-Bulgaria international meet held in Kiev, Russia, early in July. Here she chats with her father, Carl Bjorklund, CMB-11, at the family's home in Los Alamos. Her T-shirt is a souvenir of her Russian visit. Lynn, who began competing in track in 1970, runs 10 to 15 miles a day, often accompanied by her brother, Mark, who serves as her trainer. She'll continue her track activities at the University of New Mexico this fall.

Below, Anne Phillips, J-16, holds a trophy of native monkeypod wood given to her by the Princeville at Hanalei Golf Club, Kauai Hawaii, for making a hole-in-one there on May 4. Phillips was a member of the team conducting the Waso experiment on Kauai (see page 17 of this issue) and used her time off to test the local links. Her hole-in-one was made on a par-3 hole by the ocean. "You had to shoot across water. The tee was 60 feet higher than the green, so I could see the ball land and go into the hole. It was quite a thrill," Phillips says.

Phillips' prowess will come as no surprise to those who will recall that she was Women's City Champion for 7 years in Los Alamos during her years as a tournament player.



PARTICLES:
a special section

Since 1943, understanding and manipulating nuclear particles in the national interest and for the benefit of mankind has been the main business of the Los Alamos Scientific Laboratory. The towering Tandem Van de Graaff accelerator, the Clinton P. Anderson Los Alamos Meson Physics Facility (LAMPF), and Scyllac, the toroidal "tube without ends" for conducting experiments leading toward thermonuclear power, are a few of the more conspicuous physical examples of the Laboratory's involvement with particles.

Basic nuclear research fascinates the layman as much as the scientist, for there is a special excitement in the assault on the inner limits of the unknown in the never-ending attempt to learn the ultimate nature of matter and energy and the laws by which they are governed. Four recent events at LASL—a major international conference, the champagne-toasted development of the world's first polarized triton beam, the discovery of fermium-259, and an unusual LASL-designed colliding electron-photon beam device—led to this special section.

While it would take several complete issues of **The Atom** to even begin describing all of LASL's research programs involving particles, nevertheless, the articles presented here provide an overview of nuclear research in general and a few timely and dramatic developments that have taken place at LASL.

PARTICLES: AN INTERNATIONAL CONFERENCE

The field of high energy physics and nuclear structure is very rich in practical applications. But you will notice that these have been omitted from our program. We will devote all of every session to explorations in fundamental research. This reflects the opinion, held by many, that at this juncture in the evolution of our civilization, basic science is of vital importance, if not for us, then certainly for our children and grandchildren. This conference, therefore, manifests our concern for the immediate and distant future.

Without basic science, there would be no practical applications. There would be no pions for radiotherapy, no radionuclides for medicine and agriculture and industry, no energy options aside from the fast-disappearing fossil fuels; in fact, there would be no hope for achieving a viable balance between the needs and desires of humanity and the resources and limitations of our planet. So it is without apology that we dedicate the next week to pursuit of knowledge and understanding. . . .

So spoke Louis Rosen, MP-Division leader and conference chairman as he opened the Sixth International Conference on High Energy Physics and Nuclear Structure held June 8-14 at the Los Alamos Scientific Laboratory and at St. John's College in Santa Fe.

If, as Rosen said, the conference held implications for the future, it also deserved recognition in the present for some of its unusual aspects:

—The conference attracted over 500 participants, believed to be a record for international scientific meetings of this type.

On the opposite page, Hans Bethe, Cornell University, left, presides over a session at St. John's College during which L. I. Ponomarev of the U.S.S.R. delegation responds to some searching questions. Bethe earlier had reported a startling hypothesis on solar neutrinos. At left, Louis Rosen, MP-Division leader and chairman of the conference, L. I. Lapidus and Venedict Dzhelepov, both of the U.S.S.R. delegation, chat during a between-sessions stroll.

—Represented were 23 countries, including the U.S.S.R. whose 21-person delegation was believed to be the largest yet sent from that country to an international physics assemblage.

—Because the audience was larger than the auditorium could hold, a closed-circuit TV system was set up for viewing in a room adjacent to the auditorium at St. John's College, and proceedings were microwaved for viewing in the auditorium at LAMPF. This is believed to be another "first." Responsible for setting up and operating the system were E-Division, MP-Division, and Groups ISD-5 and ISD-7.

—The conference represented an aggregate international investment of an estimated quarter of a million dollars and 10 man-years of work. It was supported by the International Union of Pure and Applied Physics, the U.S. National Science Foundation, and the U.S. Energy Research and Development Administration.

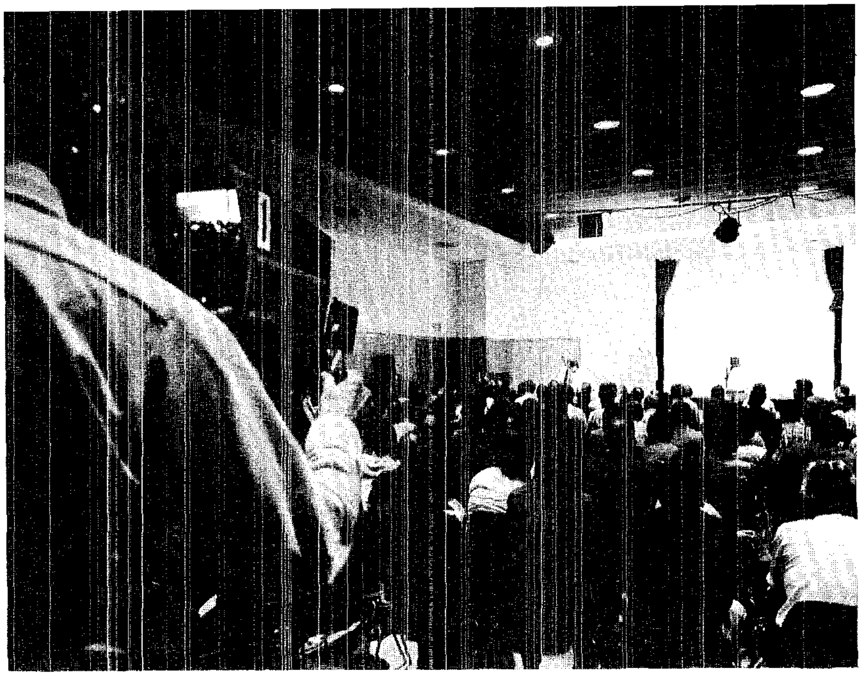
—For the first time a program to encourage attendance by young scientists, with partial financial assistance proffered, was implemented, resulting in the attendance of some 30 younger scientists. The average age of the delegates was the lowest yet. The participants comprised a yeasty mix of the enthusiasm of youth and the insights of eminent scientists, such as C. S. Wu, president of the American Physical Society, Val Telegdi and Herbert Anderson of the University of Chicago, Sir Denys Wilkinson, Oxford University, and Venedict Dzhelepov, head of the U.S.S.R. delegation.

—Coffee breaks only slightly relieved the demanding schedule during which 43 invited papers were presented, with 100 more presented in parallel sessions and 40 displayed by the "poster" technique (posted on boards or distributed as literature, but not formally presented). Over 500 papers were submitted.

Invariably, sessions during the 5 days extended beyond the nominal 5:30 p.m. closings, yet the last sessions were as heavily attended as the first. When Wu proposed an impromptu Thursday evening session on second-class currents (a nuclear binding force), it was attended by 50 delegates.

Among the highlights of the session was Hans Bethe (no stranger to LASL) arriving late, but reporting a startling hypothesis which may profoundly alter our concept of the sun's energy-generating mechanism. If so, this could have major implications in astronomy and in controlled thermonuclear research, for an understanding of how the sun sustains thermonuclear reactions has been essential to man's more or less duplicating the process on earth.

For several years, investigators have been baffled by the paucity of neutrinos emanating from the sun. Experiments capable of detecting only 1/10 of the neutrinos which "should be" emitted by the sun have produced null results. Bethe, who was awarded a Nobel prize for his description of solar thermonuclear cycles, reported that some astrophysicists are suggesting that the center of the sun may be



Proceedings at St. John's College were televised (above) under the direction of Rob Gordon, ISD-7, and Ralph Cruz, ISD-5, (below) *for large-screen projection in the auditorium at LAMPF (bottom).*

less hot than presently postulated, resulting in a substantially lower rate of neutrino production. Instead of energy being transmitted to the sun's surface and beyond by neutrinos, a novel mechanism is suggested: acoustic (or shock) waves.

This hypothesis created a wave of excitement among the delegates. It may also enhance the importance of neutrino-measurement experiments now being conducted at LAMPF.

Jeremy Bernstein, formerly of LASL and now of the Stevens Institute of Technology, writes, "Since its prediction by Pauli, the neutrino has been an endless source of surprise and delight to scientists. . . an extraordinary particle. . ." And indeed it is. More like a glob of pure energy than a particle, the neutrino has no charge, no mass at all, and reacts so weakly and infrequently with matter that a neutrino, generated in the center of the sun, could pass through a substantial amount of matter within the sun, travel at the speed of light to and through the earth, and, if it were there, could continue travelling for many thousands of years through millions upon millions of miles of solid lead before it might react with some atomic nucleus.

With its nearly total immunity to reacting with matter, it is small wonder that the neutrino is so difficult to detect (it was not identified until 1956, some 25 years following Pauli's convincing prediction). Yet, although rare, neutrino reactions do occur. One such reaction results in an atom of chlorine-37 being transformed into an atom of argon-37.

Installing a large tank of a liquid chlorine compound deep underground (to shield it from cosmic rays and extraneous background radiation as much as possible) and, after many weeks of exposure, analyzing its contents for faint traces of argon-37 provides a measurement of neutrino events, and hence of neutrino flux.

And it is a tank such as this that has produced virtually *no* sign of neutrino reactions at all.

Is the technique at fault? To find out, Raymond Davis and J. C. Evans, Brookhaven National Laboratory, and S. L. Meyer, Northwestern University, have installed several tanks at the beam stop of LAMPF where the neutrino flux is heavy and accurately known. After some months of exposure and tests, the degree of reliability and accuracy of the method will be determined. If the method is not reliable, a better method will have to be devised to detect the ethereal neutrino. But if, after all, the method is reliable, then the new, somewhat radical, hypothesis will gain strong credence.

Some startling news was also announced by several LASL staff members. In one example, Olin van Dyck, MP-7 was looking for something he didn't find, but ended up with tantalizing clues that may lead to some fundamental revisions in the ways we view nuclear structure.

Van Dyck, and collaborators from the University of Pennsylvania, using LAMPF's 800-MeV proton beam, were conducting scattering experiments to detect the possible existence of abnormal nuclear matter at much higher densities than normal. Current theories indicate that such matter could exist.

The experimental technique was to measure the velocities of rebounding protons. If a proton were to hit material of "infinite" (or immovable) mass, then it would scatter, or rebound, at exactly the same velocity at which it collided. If the proton were to hit a light nucleus, such as of a hydrogen atom, then it would rebound at a considerably lower velocity, for some of its energy would be imparted to the light nucleus, which would then move or absorb its energy in other ways. If protons hit two nuclei, identical except that one would contain abnormally dense nuclear matter, then the proton rebounding from the latter would move at a higher velocity than the proton rebounding from the "normal" lighter nucleus. Measuring velocity differences might give clues as to the existence of dense nuclear matter.

Van Dyck and collaborators did not see effects indicating the existence of this super-dense nuclear matter, but did see effects that led them into an entirely new line of investigation. The velocities recorded led them to suspect that protons were rebounding from the target nuclei (deuterium, tritium, helium, and aluminum) as if they were hitting and rebounding from substructures of nucleons within the nucleus.

Thus, instead of the various current visualizations of nuclei that show them as symmetrical groupings of tightly packed balls, perhaps scientists are not dealing with the regularity of a "tinker toy" model, but with nuclei that are, at least in some cases, granular, with clumps of nucleons here, clumps there. The ramifications for basic science may be immense, and Van Dyke's approach of measuring velocities of scattered particles may be an important tool in exploring this phenomenon more intensely.

And Darragh Nagle, MP-DO, described a new experimental approach to learn more of the nature of the weak nuclear force. While the strong nuclear force binds nucleons in nuclei (it is so powerful that it easily overcomes the electromagnetic repulsion of protons one for another), the weak force, involved in various forms of radioactive decay and interactions between certain light elementary particles, also works between nucleons.

One of science's goals is to unify the electromagnetic force and the weak nuclear force under a single theory, an accomplishment which would rank with Maxwell's milestone theories unifying electromagnetic radiation. Steven Weinberg, Harvard University, has made important advances toward such a theory, with some aspects of it already verified experimentally. However, more needs to be known before the theory can be established.

A question of great current interest is just how the weak force acts between nucleons. The strong force so dominates that effects of the weak force are extremely difficult to detect.

However, while the strong force appears to obey certain laws of conservation, the weak force appears not to. In particular, the weak interaction violates the law of mirror symmetry. In a very precise measurement of scattering from hydrogen of protons that are polarized along the direction of the beam, minute differences would show the weak force exerting a subtle influence.

To make this kind of measurement, Nagle and colleagues at LASL and the University of Illinois, using facilities of LASL's Tandem Van de Graaff accelerator, devised ways to impart a very great amount of stability to a polarized proton beam to make measurements capable of detecting changes in scattering to 1 part in 10 million.

The results of this particular experiment appear to contradict those of experiments conducted a few years ago by a Russian group. Either one of the experiments is wrong, or our picture of the weak force acting between nucleons must be changed to include the new effects.

More than one-quarter of the papers presented dealt with studies of phenomena associated with pions, those short-lived particles which by now have become standard "tools" of the experimentalists. Nevertheless, there is much more about them to be learned. Continuing experiments at LAMPF and other pion-producing facilities will broaden our understanding.

A part "business," part social, highlight of the conference was a tour of LAMPF followed by a barbecue on the premises on June 11.

As Rosen concluded in a post-conference summation, "It is now very clear that we are really bridging the gap between high energy physics and nuclear structure and that there is a very great relevance of each to the other, which only emphasizes the unity of science."

A pleased Bob Hardekopf (second from left) receives a congratulatory toast from Jules Sunier (far left), Delmar Bergen, ADW-PM (behind Hardkopf), Joseph McKibben (second from right), and Bob Emigh, P-14 (far right), at a party celebrating LASL's development of the world's first source of polarized tritons.

Making Tritons Spin Together

At the end of the working day on Monday, June 2, a visitor to the Tandem Van de Graaff accelerator on Pajarito Road would have been surprised to hear the subdued roar of talk and laughter emanating from the normally quiet technical library. From time to time, the visitor might have heard the unmistakable pop of champagne being uncorked, and if he were to have peeked through the door at the right time, he would have seen guests such as Henry Motz, P-Division leader, Roger Perkins, P-Division alternate leader, and Dick Taschek, associate director for research, raising their glasses in a congratulatory toast to various members of Group P-9 (Tandem Van de Graaff Experiments).

Obviously, and despite the fact that the volume of champagne proffered provided but a ceremonial sip for each guest, a party was in progress to celebrate some unusual and important event.

And that was exactly what was happening. Bob Hardekopf and Lou Morrison, both P-9, with vital advice and support from individuals such as Joseph McKibben and Jerry Ohlsen, both P-9, and P. W. Keaton, E-Division leader, and from a number of groups and the Shop Department, had devised the world's first source of polarized tritons.

What's more, the ingenious equipment they devised had performed nearly flawlessly from the beginning in an intensive series of early experiments conducted by Hardekopf, Ohlsen, Keaton, Nelson Jarmie, Ray Poore, Ed Flynn, and Jules Sunier, all P-9, Lynn Veeser, P-3, and visiting staff members Richard Walter, Paul Lisowski, Jean-Pierre Coffin, and Joe Sherman.

To nuclear scientists, the party celebrated the solution of a long-standing and extremely tricky technical problem, which resulted in the addition of a valuable new technique to their investigative repertoire. To laymen, the celebration was something of a bewilderment. Why all the elation over polarized tritons—and what are they, anyhow?

In the increasingly sophisticated world of nuclear research, for some measurements it is no longer sufficient to shoot a beam of particles at a target and record the reactions. For some experiments, that's like performing surgery with a meat cleaver when what investigators would really prefer—or must have, in many cases—are sharp, fine scalpels.

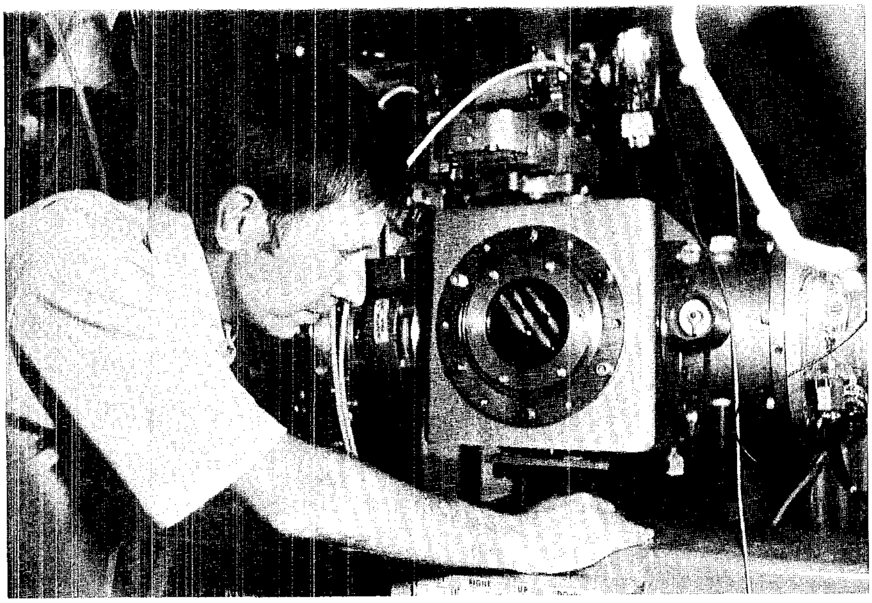
Which is why several particle beams at LASL can be, and frequently are, polarized nowadays.

Most particles used in accelerator beams have spin; having spin, they also have poles about which to spin. In an unpolarized beam, the poles point every which way.

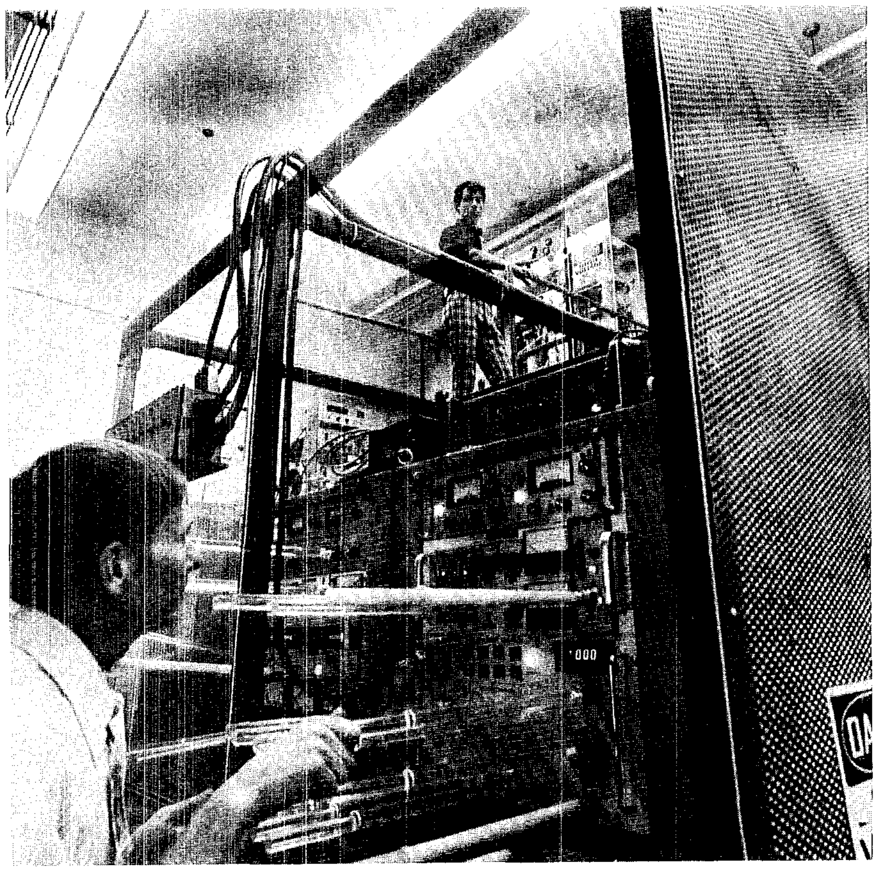
In a polarized beam, most of the particles will have their poles *aligned in the same direction with* their spins up or down. Upon collision or interaction, these particles will deflect preferentially to the left or right depending upon their spin. The action is comparable to imparting substantial english to a cue ball in billiards; the ball will deflect predictably to the left or right upon striking another. There are a number of spin-dependent effects of interest to physicists—including the characteristics of spin itself—which can only be measured with a polarized beam.

Enter the triton—a singularly useful particle for basic research. The triton is the nucleus of a tritium atom, containing 1 proton and 2 neutrons. Tritium is an isotope of hydrogen that plays a key role in thermonuclear reactions. Its characteristics of spin and mass also make it ideal for studying certain interactions among light elements. In addition, the triton is an excellent "carrier" of neutrons to form new nuclear combinations in heavy elements. The positively charged proton allows the triton to be accelerated electrostatically and focused magnetically; upon interacting with a heavier nucleus, the proton will be repelled while the neutrons may join the nucleus to form a new isotope (see story on page 9 of this issue).

The problem with tritium, though, is that it is radioactive, and so producing a triton beam requires elaborate mechanisms to guard against radioactive effects. Consequently, LASL is one of only 2 or 3 laboratories in the world that have developed a triton source of any kind and, in fact, is a leader in this specialized technology.



Above, Hardekopf checks the electrostatic mirror which is essential to the system. It deflects polarized tritons at right angles into the accelerator without changing the direction in which their poles point. Below, Lou Morrison watches as Hardekopf manipulates controls of the polarized triton source. The acrylic shield and control extensions are safety measures to prevent contact with the device, which generates high voltages.



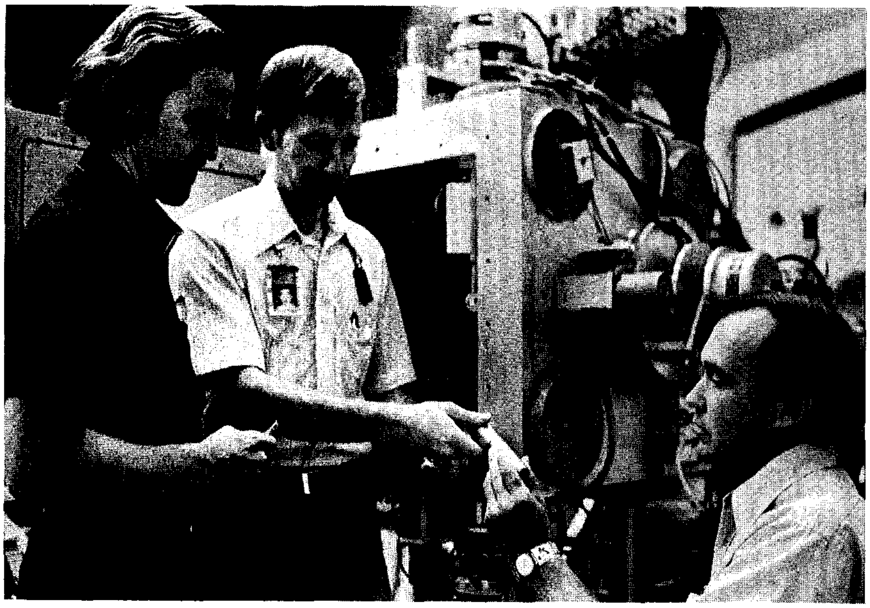
Until now, residual tritium gas from ion-source operations at LASL has been caught in a trap of charcoal and liquid nitrogen. These materials were then handled and disposed of with procedures normally employed for radioactive waste.

But Hardekopf and his colleagues believed that a system could be developed to recirculate the tritium, thus minimizing the waste disposal problem while making a greater volume of tritium available through recycling.

Consequently, they designed and constructed a recirculation loop which recovered residual gas from the ion source and directed it back to the source to be reused. It was a technological accomplishment that has paid off in a tritium flow rate 3 to 10 times greater than practical with the previous method.

In developing and using the polarized triton source, the investigators profited by polarization techniques developed previously at LASL. McKibben, Ohlsen, and George Lawrence, P-11, had developed methods of polarizing proton and deuteron beams in the 1960's, and McKibben's consultation proved invaluable in developing the new source. Thus, although polarized beams are a relatively new technology (the first international polarization symposium was held in 1960, the 4th will be held this summer, at which time the LASL investigators will present several papers on their accomplishment), the principles for polarizing tritons were known.

Applying them was a different matter. In the first stage of the device that was developed, atoms in tritium gas are stripped of their electrons to form a plasma. The ions are directed into a cesium charge-exchange canal where a special type of atom—metastable atoms, or those in an excited state with a relatively long lifetime—are produced. Polarization of these atoms is accomplished in a radio-frequency cavity where magnetic and electric fields "filter" out those atoms whose spins have not become properly aligned but allow the correctly spinning atoms to travel down into a tube where collisions with argon gas then transforms them into negatively charged tritium ions (these are tritium atoms with an extra electron added to their normal 1-electron shell). The negative charge allows the ions to be accelerated by the positive potential in the Van de Graaff accelerator. The electrons are later stripped from the nuclei in the accelerator, leaving just the tritons with their positive charge.



Nelson Jarmie, Hardekopf, and Ray Poore inspect a collimator for the scattering chamber in the background. Solid-state detectors measure scattering effects of polarized tritons.

A complicated process, but one that produces a beam in which 80 to 90 per cent of the tritons are polarized. A polarized proton source using the same principles and much of the technology developed for this source is under construction for LAMPF.

Because the entire device is installed vertically, polarized tritons arrive at the horizontal Van de Graaff beam with vertical axes. To keep them that way, an electrostatic mirror was devised that deflects the ions 90° without changing the orientation of their axes.

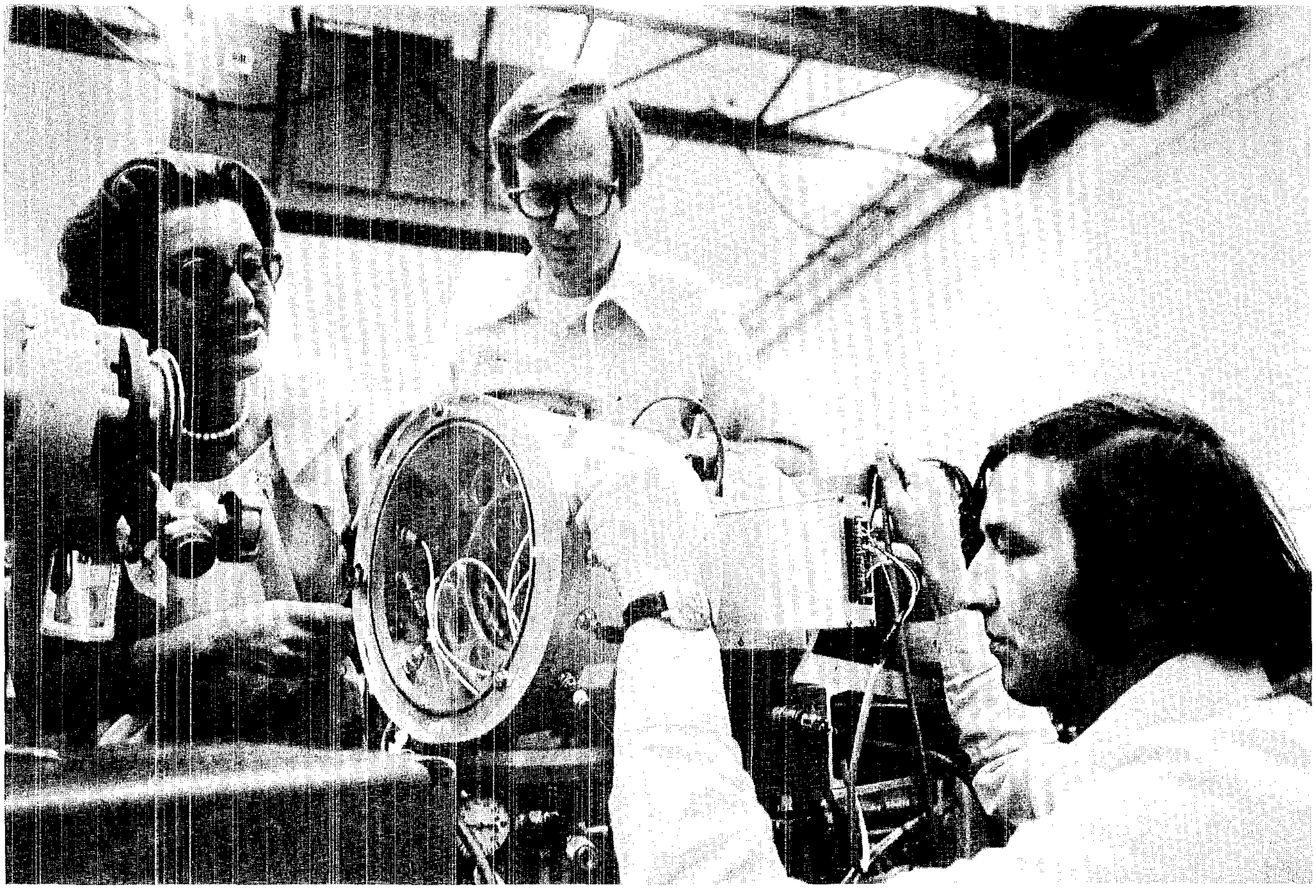
Among the many applications of the polarized triton beam will be the study of nuclear forces as they pertain to nuclear structure. Another application is the study of interactions important in a thermonuclear reactor to utilize the energy produced that may involve the reaction of a neutron (1 nucleon) with an atom of lithium (6 nucleons). The reaction of a triton (3 nucleons) with a helium nucleus (4 nucleons) gives measurements that can be interpreted to apply to the former reaction because they both involve 7 nucleons. Such experiments have already yielded valuable data. In the same way, other few-nucleon systems involved in thermonuclear reactions may be studied.

But the applications have only just begun. Essentially, investigators now have a new and versatile tool at their disposal for conducting basic research, one with superior analyzing powers that also makes possible experiments never conducted before. There is no doubt that the new beam of tritons, whirling in unison, will lead to new knowledge.

And that's what the party in the library at the Tandem Van de Graaff on June 2 was all about.

THE CASE OF THE MISSING ISOTOPE

The novel mechanism that captured the missing isotope, fermium-259, is set up by principal investigators Darleane Hoffman, Jerry Wilhelmy, and Josef Weber, all CNC-11.



How do you discover an isotope which is believed to come to life in the caldron of a nuclear explosion, but for which proof of its existence had never been found?

The answer is to create that isotope yourself—if you can—under somewhat less extreme laboratory conditions. In the process, perhaps you'll learn something about the isotope's characteristics, including clues as to why it could never be captured before.

The mystery begins at the Nevada Test Site during special underground experiments in the mid and late 1960s to create and detect transuranium (heavier than uranium) elements and their various isotopes. One of the isotopes that scientists were confident they would find in the aftermath of the explosions was fermium-259. Fermium itself (in this case the 255 isotope with a half-life of 20 hours) had been discovered in debris created by "Mike," the first test of a hydrogen device in the Pacific. It was named in honor of Enrico Fermi. Only 6 heavier elements are known: mendelevium, nobelium, lawrencium, and the as yet unnamed elements 104, 105, and 106.

But test results in Nevada were disappointing insofar as fermium-259 was concerned. Other isotopes of fermium, and other transuranium elements, were recovered as predicted, but where was the missing fermium-259?

Among others, Darleane Hoffman, Josef Weber, and Jerry Wilhelmy, all CNC-11, and a group of researchers at Lawrence Livermore Laboratory, Ken Hulet, Jerry Landrum, Ron Lougheed, and John Wild, wanted to know. And they hypothesized that the reason fermium-259 had never been detected was that it decayed more rapidly than theory predicted—so rapidly that it's half-life might be measured in minutes or seconds rather than in hours as had been previously assumed. It would simply disappear before post-test analyses could be made. The villain in this scientific whodunit just might be time.

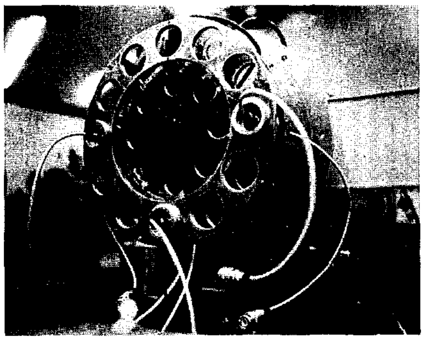
Therefore, the investigators reasoned, if fermium-259 were ever to be found, it would have to be created by laboratory means and detected before it had time to vanish.

To accomplish this, the nuclear chemists, with valuable support from Group P-9 and the CNC-11 Radiochemistry Group Shop, devised an experiment which held promise of doing just that. They decided to produce fermium-259—if it could be produced—by bombarding fermium 257 with tritons at 16 million electron volts (MeV), an energy calculated to optimize the formation of fermium-259 by the addition of 2 neutrons from the triton to the fermium-257 nucleus. The experiment required the most intense beam possible, and thus the triton source at the Tandem Van de Graaff accelerator, the only facility known to be capable of delivering 10 microamps or more of 16-MeV tritons, was chosen for the experiment.

The technique used was to mount a sample of fermium-257 (an incredibly small amount—4/10 of a picogram, or less than a millionth of a billionth of a pound, representing the entire world supply at the time) on a berylium foil and place it in the triton-beam target area. Reaction products, hopefully containing fermium-259, would recoil from the target and be captured on thin carbon foils mounted on a wheel.

After a brief exposure, the wheel would rotate, in 3/10 of a second, to a new angular position between stationary counters mounted on wheels which do not turn. As another carbon foil collected fission products, counting would proceed on the foil just exposed. During the period of rotation, the triton beam would be deflected to minimize unwanted

The heart of the mechanism is an arrangement of 2 stationary wheels and a rotating wheel that moves collector foils between the target and pairs of counters.



reactions and damage to the mechanism.

This procedure was repeated hour after hour as measurements were made, a number of carbon foils on the wheel each collecting fission products from the target, then rotating to have the products counted, then back into position to collect again.

If the principle was simple, the equipment was not. A special motor was obtained, and initial engineering and construction was accomplished, at Lawrence Livermore Laboratory. The CNC-11 Radiochemistry Shop, under the direction of Claude Edwards, SD-5, aligned the gearing and fabricated additional parts to complete the mechanism that would perform the intricate stop-and-go movements.

The miniscule amount of fermium-257 used in the experiment was obtained from the Oak Ridge Laboratory's transplutonium production facilities where it had been built up from plutonium in an intricate multiple neutron bombardment process. Its half-life of 100 days made shipment and usage of the material feasible.

Adding to the complexity of the experiment was the requirement that it be conducted in a vacuum. This reduced background effects and prevented the formation of a film on the target which would have "smothered" the reactions.

The first experiment, which ran 160 hours, was beset by a number of mechanical and electronic problems which limited the amount of data obtained. Corrections were made and the second experiment, requiring 120 hours, produced results with greater clarity. More than 500 fission events were recorded by a computer system—a small number, but sufficient to prove that fermium-259 did indeed exist.

And fermium-259's half life, according to preliminary analysis by the research team, is only about 1.5 seconds, accounting for its mysterious absence from products detected after the special tests at the Nevada Test Site.

The experiment yielded other interesting results. For one, it appears that fermium-259—which has more neutrons than any isotope yet produced—may have the most symmetrical mass distribution of any of the heavy elements, inasmuch as a very large percentage of its nuclei break into 2 equal or nearly equal fragments following spontaneous fission. And traces of another transuranium element, einsteinium-256, in a new energy state, were found, suggesting further investigations to determine its properties.

If the strange and exotic subnuclear particles associated with nuclear forces represent one extreme on the frontier in atomic research, (see page 2 this issue) the artificial, short-lived, and superheavy elements and their isotopes beyond uranium represent the other. Physicists speculate that elements beyond the presently known 106 elements can be created, but, being extremely unstable, may exist for much briefer intervals than fermium-259. However, theory suggests that beyond the known transuranium elements, an "island of stability," or a sequence of extraordinarily heavy, but more stable, elements may exist, or can be produced artificially. The frontier beyond uranium is one whose shape is yet to be fully discerned.

But by solving the case of the missing isotope — fermium-259 — LASL and LLL scientists have helped make this frontier just a little bit clearer.

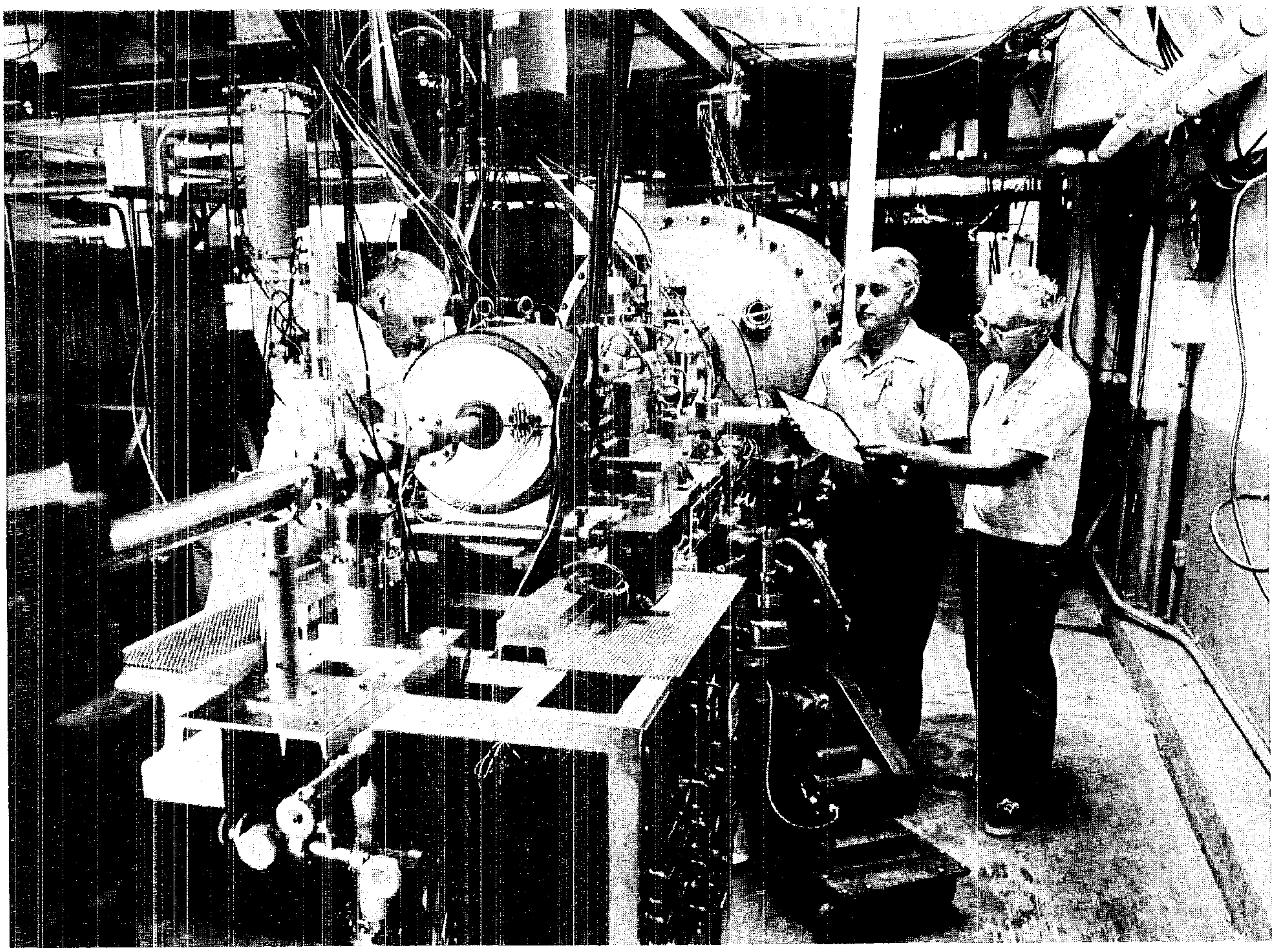
BRINGING ELECTRONS AND PHOTONS TOGETHER —HEAD ON!

John Winston, E-3, Bill Stein, P-DOR, and Bob Zickefoose, E-2, make adjustments on the linear electron accelerator. The beam flows from the source in back towards a target chamber at front left.

Take a beam of electrons, collide them head on with a beam of photons, and what do you get?

One thing you get, if science fascinates you, is an Einsteinian parlor game. For instance, if an observer could ride the electron—accelerated to more than 99 per cent of the speed of light—and the photon were moving, of course, at the speed of light, at what speed would the approaching photon appear to be moving on its collision course in respect to the electron?

The answer is not almost twice the speed of light as simple arithmetic and Newtonian physics would indicate, but that the photon would appear to be approaching the electron at exactly the speed of light. In the realm of relativity, which becomes meaningful in the reaches of space and at the very high speeds at which accelerated particles move, the speed of light to an observer



"Intriguing as these relativistic conundrums may be, colliding electrons and photons will serve a special and very useful purpose at the Los Alamos Scientific Laboratory. The collisions produce soft x rays which may be fine-tuned over a wide range of energies. . . ."

does not vary regardless of the motion of the light source, or of the motion of the observer relative to it.

Further, while the observer on the electron would be unaware of it, a real-life observer in a laboratory would be very much aware—in fact, would have to take the phenomenon into account in his calculations—that the electron at such speed would have gained substantially in mass.

Intriguing as these relativistic conundrums may be, colliding electrons and photons will serve a special and very useful purpose at the Los Alamos Scientific Laboratory. The collisions produce soft x rays which may be fine-tuned over a wide range of energies (and thus wave lengths) with great precision.

Which is why Bill Stein, P-DOR, Bob Zickefoose, E-2, John Winston, E-3, Phil Bendt, P-2, and Mike Fazio, summer graduate student, are assembling the equipment and testing it now in a basement laboratory in the Physics Building. The linear accelerator generating the electron beam is installed and in operation. Numerous tests have been conducted on it. The neodymium glass laser unit, the source for the photon beam, is being installed and the entire assemblage will go into operation later this year.

The linear accelerator for electrons was designed and built at LASL. It incorporates one of the most useful design principles developed at the Clinton P. Anderson Los Alamos Meson Physics Facility, the standing-wave side-coupled radio-frequency cavity, and MP-Division lent valuable support in personnel and assembly facilities to P-Division for this application.

At present the accelerator's beam, designed to operate at energies from 2 to 7 million electron volts (MeV), is directed into a lead-shielded target area for tests, such as with the lucite disks described on the inside front cover. Soon this target will be moved, to be replaced by an interaction chamber where the electron and photon beams will collide. The electron beam will be modified with bending magnets. Among other functions, the magnets will "weed out" electrons of greater or less energy than desired, inasmuch as electrons of different energies travel at slightly different speeds and their differing momenta cause them to deflect at different angles within the field. Stein predicts that, with the bending magnets installed, the energy of the electrons can be controlled within 1 per cent.

The laser-generated photons will enter the reaction chamber via a system of mirrors and perhaps prisms—it would be a bit rough on the laser to be facing directly into the electron beam. Interestingly, most of the photons will backscatter within a very narrow angle—despite the fact that many will collide with electrons somewhat off of center. According to Euclidian geometry, these photons should "ricochet" from the electrons at wide angles. But again, this is a relativistic realm where different laws of geometry prevail, and one half of the colliding photons will recoil within a narrow conical region of less than 6°.

The photons absorb a great deal of energy in the collision reaction—a 400-fold increase when the electron beam has an energy of near 5 MeV, for example. Since energy must be conserved, or accounted for, and Einstein showed that no particle or form of energy can exceed the speed of light, what happens to this huge input of energy, considering that the photons are already travelling at the speed of light and cannot increase their speed?

The extra energy imparted to the photon manifests itself in a radical shift in the photon's wavelength. The photon enters the reaction chamber with a wave length of 1060 nanometers (billionths of a meter), which is in the invisible near-infrared region of the electromagnetic spectrum. It collides, backscatters with no gain in its velocity, but its wave length shifts across the visible spectrum to the soft x-ray region between 10.6 and 1.2 nanometers. Photons with short wave lengths contain much more energy than those with long wave lengths.

Visualizing the x-ray photons as recoiling back through a narrow conical region, the photons travelling along the central axis of the region have greater energy, the photons toward the edges less. The investigator can use the entire x-ray cone, if uniformity of energy is not critical, and obtain a greater quantity of x rays for his experiment. Or he can use a cone of smaller angle where the photon energy will be more uniform, but the number of x-ray photons less. Within such a small angular acceptance, the energies of the photon will be so nearly uniform that, for most practical purposes, the x rays may be said to be "monoenergetic" or monochromatic." And, x-ray energies can also be controlled by altering the energy of the electron beam.

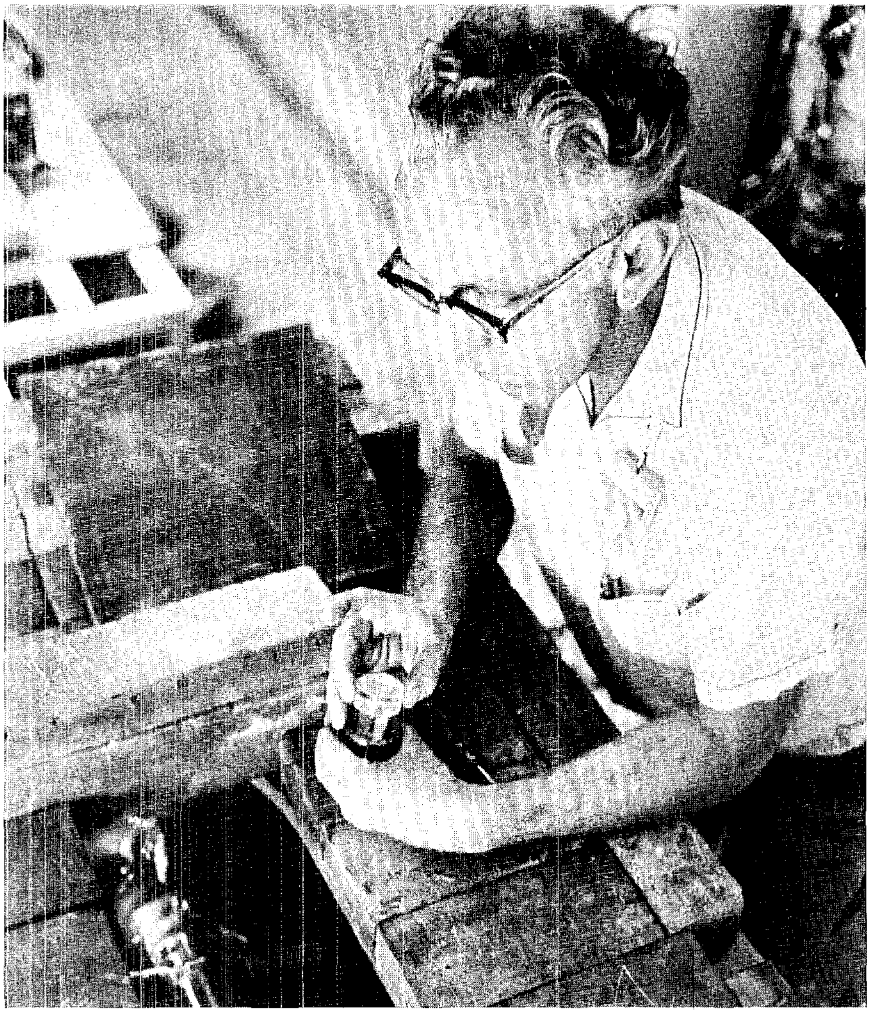
As Stein sums it up, "Some x-ray sources can be more monoenergetic but with less latitude for producing a variety of energies. Other sources can be operated at various energies, but are not monoenergetic in that the beam will not be pure, but will consist of photons with many different energies. Our new source will provide both variety and monoenergetic x rays."

And it will provide a "plus" that may prove of considerable interest to experimentalists. Since the input laser photons are polarized, the x-ray photons produced in collisions will also be polarized. The technology and use of polarized particles of various types have, as is obvious in this special section, made considerable advances in recent years, and it seems certain that this particular feature of the x-ray source will find frequent application.

One experiment planned for the new machine is the measurement of photoelectric effects, or the effects of photons interacting with electrons in the various shells of atoms. Investigators would like to know why photons "pick out" certain electrons in the different shells and measure the absorptions and cross sections. The new source of finely tuned, nearly monoenergetic soft x rays will make a broad range of such studies easier to conduct.

Experiments like this are expected to provide data useful in understanding energy absorption and transport processes in thermonuclear reactions, applicable both to weapons design and the development of the peaceful uses of thermonuclear energy.

Creating head-on collisions between fast-moving electrons and photons creates more than some interesting relativistic effects. It creates a versatile and valuable new method for understanding better the nature of matter, adding to the already impressive array of basic research tools available to the investigator at LASL.



Zickefoose mounts a lucite puck before placing it in the target chamber to test the electron beam. The method is crude, but fast, simple, and economical. The effects of the electron beam are shown below and on the front cover.

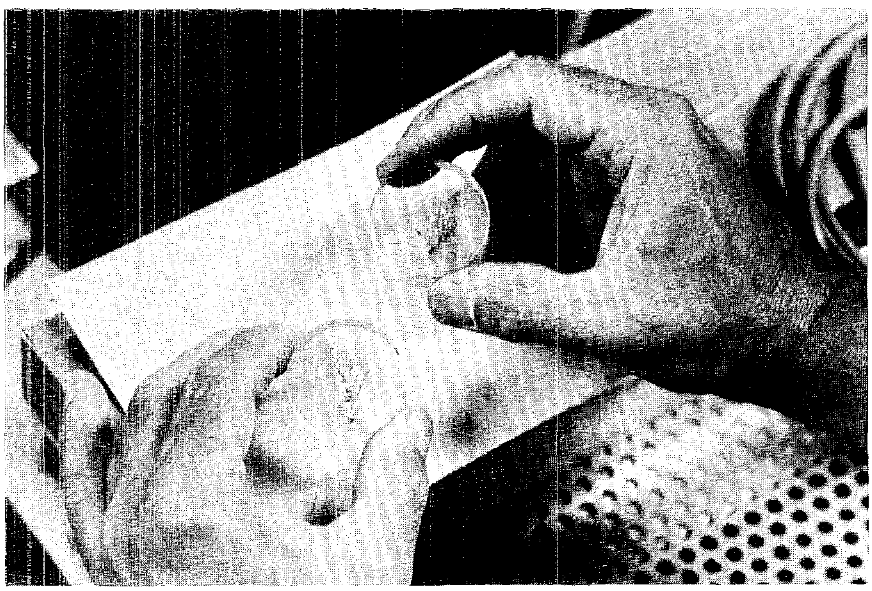
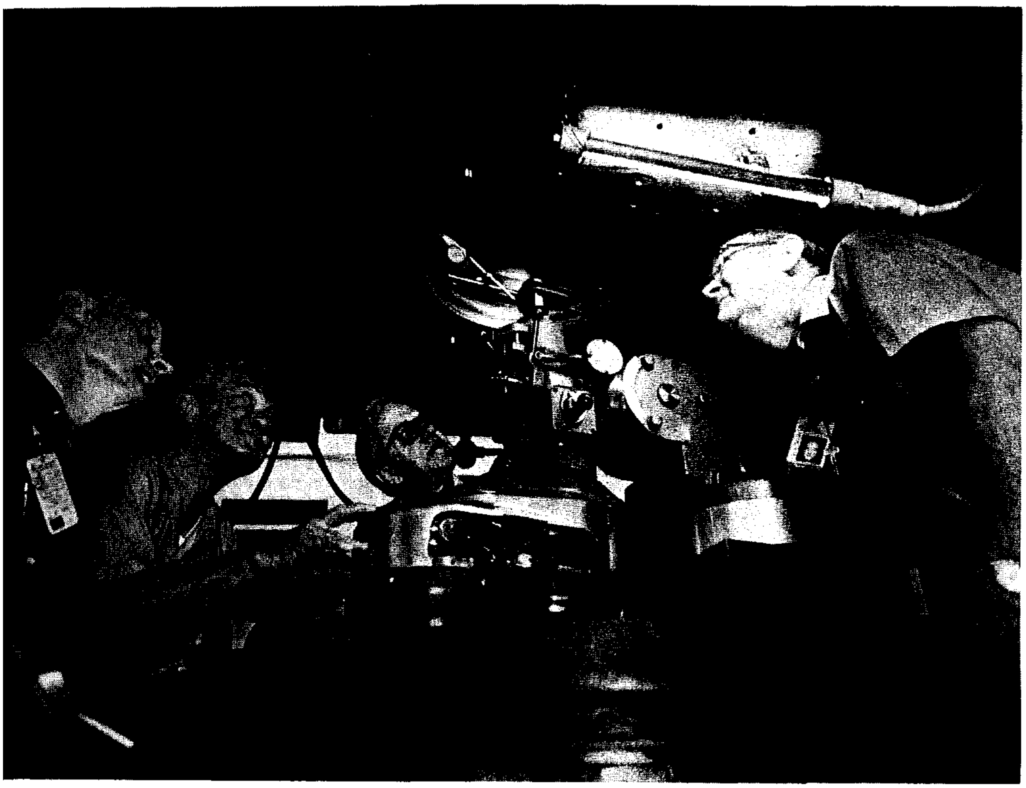
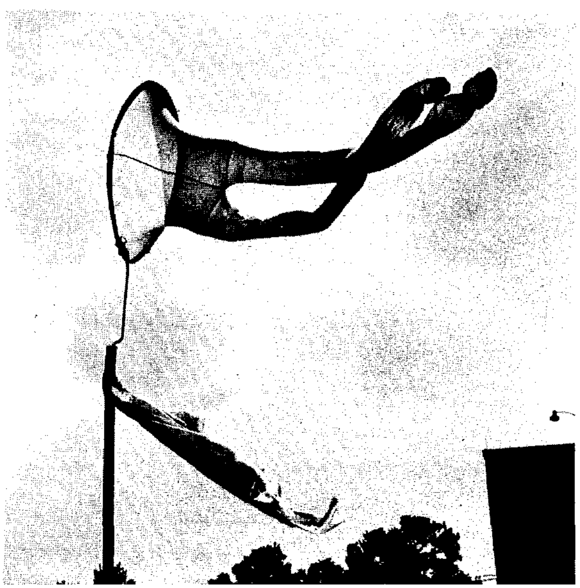


PHOTO SHORTS



Things you never learn in machinists' school: take a piece here, a piece there, put it all together and you can drill a hole where the textbook says it can't be done. Which is what William Heath, WX-3, Ed Sass, Richard Schmitt, and Coleson Ruminer, all SD-5, are doing here at S-Site. They mounted a head from a Bridgeport mill upside down on a rotary table from another machine, which in turn was placed on a riser borrowed from yet another machine. Fellow machinists laughed at the Rube Goldberg-like contraption, but it worked well enough to counterbore a 17" diameter hole in the 4-foot-thick-steel platen of the press so that a special die could be mounted in it.

Summer must be the silly season at LASL as signs of humor, intentional or otherwise, broke out last month. At left, a storm may be brewing as someone finds her pantyhose being used as a windsock at TA-46. And some wag went to a great deal of trouble to neatly letter the little "TA-33-77 Ant Hill" sign for the mound below.



About 50 of the 200 attendees to the ERDA Safeguards Briefing and Demonstration held in Los Alamos on June 16 here view displays in the Nuclear Safeguards Building at Ten Site. The attendees, which included Rudolf Rometsch, inspector general of the International Atomic Energy Agency, were representatives from government and private nuclear facilities, and the displays were of equipment for the assay of fission materials and for materials control developed by Groups A-1, A-2, and CMB-1. The participants visited Sandia Laboratories in Albuquerque the following day, with many continuing on to New Orleans to attend an Institute of Nuclear Materials Management conference there.

During a month-long visit to the U.S.S.R., Director Harold Agnew gave a lecture at DUBNA, a scientific laboratory near Moscow, on May 16. Here Agnew, right, responds to a question by Academician Bruno Pontecorvo, left. Standing with his back to the camera is V.P. Dzhelepov who, a short time later, headed the U.S.S.R. delegation to the International Conference on High Energy Physics and Nuclear structure in Santa Fe and Los Alamos (see page 2). Agnew and his wife, Beverly, later took the Trans-Siberian Railroad across the Soviet Union for the return portion of their trip.

short subjects

Honors: **William Stratton,** A-5, has been elected to the Board of Directors of the American Nuclear Society. Stratton is also a member of the U.S. Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards.

Donald Kerr, alternate Q-Division leader, has been named a consultant on the U.S. Army's Scientific Advisory Panel.

Keith Zeigler, C-5 alternate group leader, has been elected a Fellow of the American Statistical Association.

Robert Van Gemert, SP Department head, has been elected president of the Albuquerque Chapter of the National Contract Management Association.

Valgene Hart, MP-8, received an Entry of Merit honorarium and lapel medallion from the James F. Lincoln Arc Welding Foundation for his paper describing a quadrupole magnet support at LAMPF.

A flurry of recent volcanic activity in Hawaii and the Pacific Northwest has resulted in LASL teams making field trips to conduct investigations in the affected areas. In Hawaii recently to observe activity in Mauna Loa Volcano were **Grant Heiken, Ron Gooley,** and **Thomas McGetchin,** Q-21, and **Sidney Stone,** J-10. Studying volcano activity in the Cascade Mountains, which stretch from Northern California to the Canadian Border, are Heiken, McGetchin, **John Eichelberger,** Q-21, **Eiichi Fukushima,** CNC-4, and **Len Margolin,** T-3. Eichelberger, and **Bernard Chouet** of MIT were trapped near the summit of Mount Baker in Northern Washington in early May by a 36-hour snowstorm that forced them to dig their way out of a collapsed tent before rescuers could reach them. A remote camera mounted near the summit of the active crater at Baker is delivering excellent black and white real time pictures of the summit on a 15-minute schedule.

Deaths: **Charles D. Brown,** MP-7, mechanical technician; **Hunter Hill,** CMB-5, staff member; **Jimmie H. Smith,** Q-25, mechanical engineer.

From ERDA: **Herman Roser** has been named manager of the Albuquerque Operations Office (ALO), succeeding **H. C. Donnelly** who retired May 23. Roser had been serving as acting manager since Donnelly's retirement and, before that, had served as deputy manager since September 1, 1972.

A native New Mexican, Roser was with the Zia Company at Los Alamos from 1948 until 1961 when he joined the AEC in Los Alamos as assistant area manager for community affairs. He subsequently became deputy area manager in 1964 and area manager in 1967, a position he held until he was named assistant director of the Division of Military Application for the AEC in Washington, D.C.

Roser, who has received numerous awards, recently received the AEC's Distinguished Service Award for his outstanding service in managing a variety of national security programs.

Richard Malone has been appointed area manager of the Sandia Area Office, succeeding **Robert Scott,** who was appointed assistant manager for administration. **Richard Torres,** formerly program analyst in the ALO Weapons Development Division, has been named director of the ALO Administrative Budget Division. **Zane Hopper,** formerly director of the Organization and Personnel Division at the Idaho Operations Office, has been named to the same post at ALO. **Charles Romero** has been appointed deputy director of the ALO Organization and Personnel Division.

Retirements: **Homer O. Blackledge,** SD-5, laboratory machinist; **Virginia W. Blackledge,** AO-1, records supervisor; **Donald E. Chamberlin,** SD-1, laboratory instrument maker; **Irving Goldfarb,** SD-5, laboratory machinist; **Daniel J. Kelly,** CMB-1, chemical technician; **Victoria E. Mitchell,** H-9, chemical technician; **Evelyn M. Newell,** ISD-3, illustrator's assistant; **Jane Robyn,** J-12, secretary; **Beatrice L. Smith,** AO-1, junior accountant; **Eva E. Ward,** WX-3, clerk; **Donald L. Winchell,** WX-3, staff member; **Francis N. Hayes,** H-9, staff member; **George E. Jaynes,** CMB-6, staff member; **Philip W. Kazmier,** SP-11, buyer; **Paul E. Miller,** WX-3, machinist lead operator.

Above the clouds on Mt. Haleakala, Maui, the Loxia observing team, with their optical equipment, watched for a break in the weather night after night. On the seventh night, the break came and Loxia produced the fireworks shown on page 20.

Cutting Across the Magnetic Grain

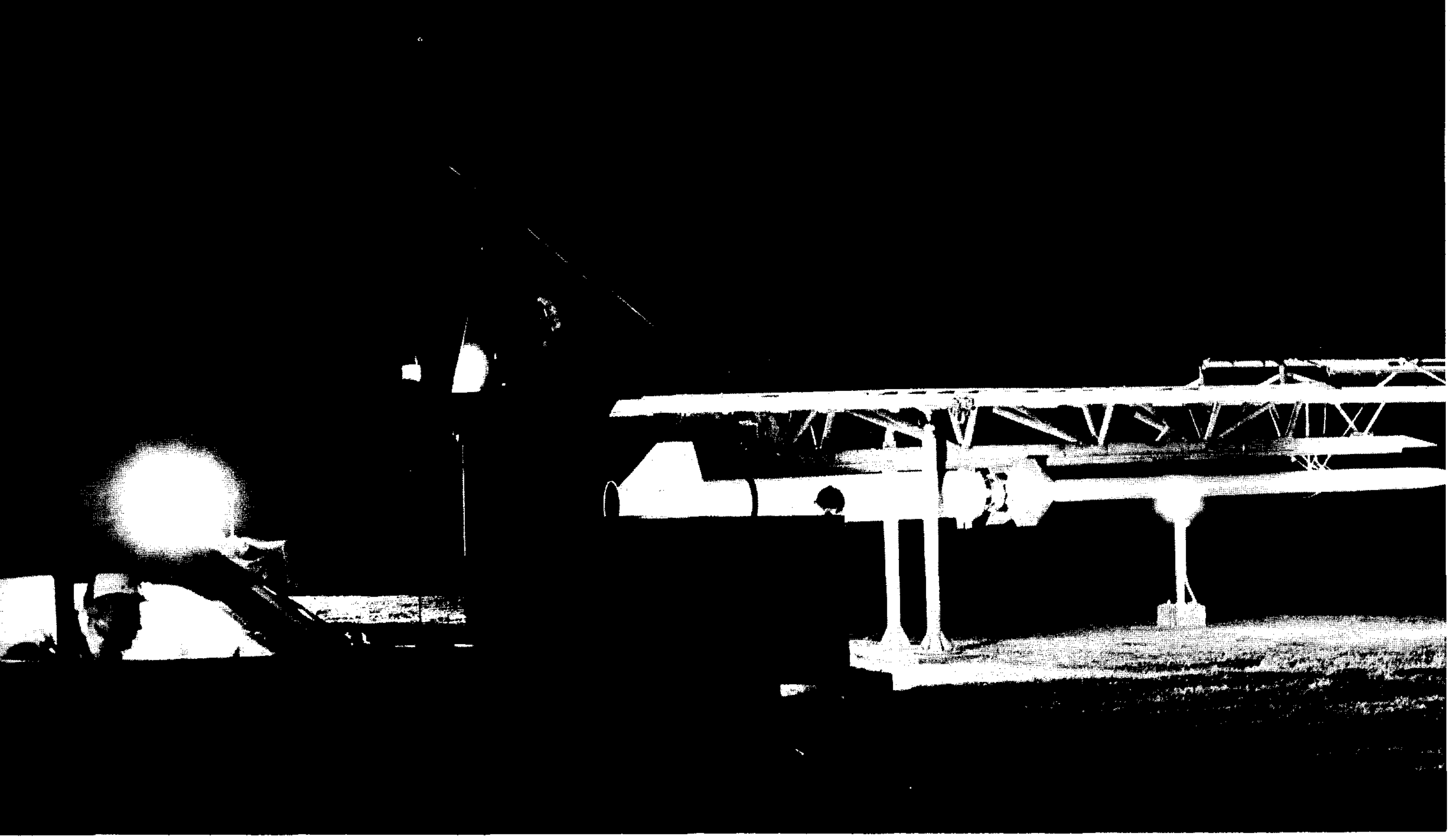
Story and photos by Bill Regan

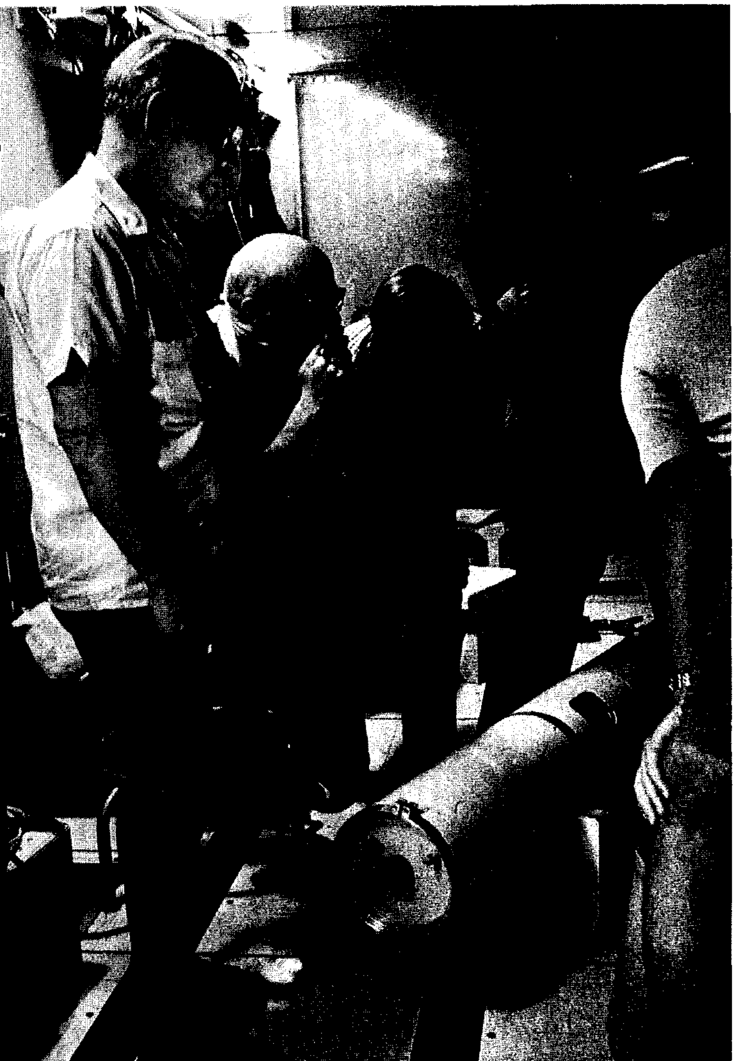
Energetic space physicists from the Los Alamos Scientific Laboratory's J-Division logged 2 more successful investigations of the earth's ionosphere using small sounding rocket payloads fired from the Hawaiian Islands in May. The long-term study will continue with a late fall experimental program in the Arctic.

Groups J-10 and J-16 employed 2 different techniques to add to man's knowledge of the protective environment of magnetic and electric fields which surround the earth and shield the lower atmosphere from the constant stream of charged particles pouring in from outer space. Waso, an experiment to measure electronically the transmission of an electromagnetic pulse (EMP) signal through the ionosphere, was sponsored by J-16 while J-10 conducted the Loxia experiment, a barium plasma injection designed to allow scientists to study optically the behavior of charged particles directed across magnetic field lines. Unlike previous barium-injection experiments where the ion stream was aimed along a field line, the Loxia injection was intentionally oriented at a large angle to the field.

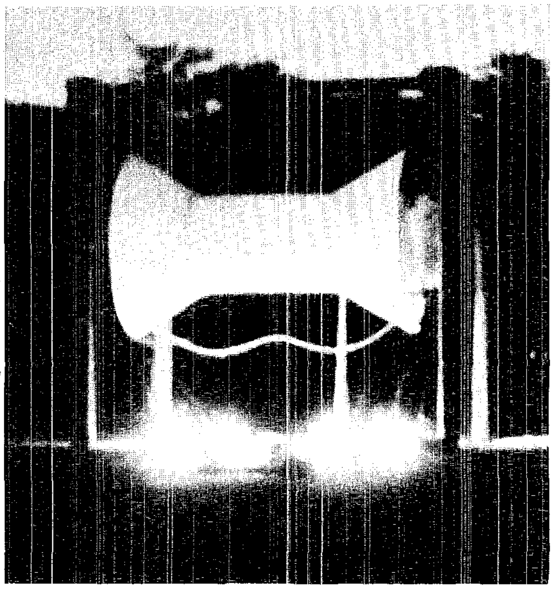
The Waso experiment employed a 2-million-volt pulse generator to send EMP signals into the ionosphere where the signals were recorded by detectors aboard the rocket. The pulser, located about 400 meters from the rocket launch site at the Energy Research and Development Administration's Kauai Test Facility at Barking Sands, discharged to emit a signal every 16 seconds.

At 4 a.m., May 9, Test Director Al Huters of the Albuquerque Sandia Laboratories rocket engineering team gave the firing signal which blasted the Terrier Sandhawk rocket on its way. Ross Buchanan and Owen Barnes of the Denver Research Institute operated the pulser starting at 58 seconds after launch to generate 35 signals during the 10½ minute rocket flight. In a telemetry trailer nearby, a happy Clarence Benton, Waso project director, and J-16 Group Leader Bob Peterson listened to the incoming data signals for 349 seconds of the rocket's flight to an





Above, the Terrier Tomahawk rocket which carried the Loxia barium payload to an altitude of 360 km was poised and ready for the seventh and last countdown. At left, Clarence Benton and Bob Peterson, at left foreground, both J-16, watch anxiously as their Sandia colleagues troubleshoot a problem in the Waso rocket payload. Below, ballet-like scenes like this were enacted every night at the Barnyard optical station on Kauai as observers adjusted equipment and watched for clouds. ON THE OPPOSITE PAGE: *Top, lightning-like flashes crackle around a 2-million-volt EMP simulator as it discharges to send a signal through the ionosphere for the Waso experiment. Second from top, Doug Dunbar, EG&G, watches video monitor. The disk on the screen shows not the ejection, but an electronic effect. Third from top, Morris Pongratz, left, J-10, Loxia project director, and Bob Jeffries, right, J-10 alternate group leader and scientific advisor for Loxia, receive weather reports. Below, Gordon Smith, foreground, and Casey Stevens, standing, both J-10, scan weather over the Barnyard optical station—a type of scene that became all too familiar.*



apogee of 405 kilometers. The telemetry system operated for 281 more seconds as the payload descended. Then a drogue parachute opened to slow the payload's descent into the ocean where a balloon flotation device and homing beacon marker permitted recovery of the package, the most complicated and expensive of the 9-year program.

J-16 has been involved in a continuing investigation of what happens to EMP signals as they pass through the ionosphere. Working closely with rocket engineering colleagues from Sandia for more than 10 years, Benton and his J-16 team have developed and refined suitable instrumentation to carry out their research mission since the first such rocket flight in March 1966.

With Waso out of the way, J-10's space physics team became more and more frustrated by unfavorable weather and rocket problems. Loxia, first scheduled for May 7 by Morris Pongratz, J-10 project director, was scrubbed for 6 successive evenings. On 2 occasions the weather was perfect for the launch and the countdown went all the way to zero, but when the firing signal was given the rocket motor failed to ignite. Checkout of the usually reliable and well-tested system uncovered an entire lot of defective initiators.

As the LASL scientists' frustration increased so did the interest of people all over the islands. Hawaii residents and tourists alike became eager sky watchers for the barium-rocket display as the news media called daily attention to the night-by-night rescheduling of the experiment.

On May 12 the evening window ended and it was necessary to schedule the launch for a pre-dawn event time of 4:40 a.m. May 14. On this seventh try, the Terrier Tomahawk Loxia rocket roared off the launcher right on schedule. The Honolulu Star Bulletin summed it all up with a headline reading "BARIUM ROCKET FINALLY DOES ITS GAUDY THING."

And Carl Lyon, J-1 operations officer, suffering from a good case of telephone fatigue from answering radio news media calls said, "At last. I wonder if it looked like I said it would?"

Gaudy it was, too, as the barium plasma reflected the sun's rays in streams of blue, green, and magenta at an altitude of 360 km. Although the barium stream was directed at a large angle to the magnetic field by the high-explosive shaped charge, it promptly bent over as it became ionized and followed magnetic field lines. In a matter of a minute it streamed 450 km to the south. Some minutes later the visible length of the arc was about 3500 km.

Observers at scientific optical stations on 2 islands reported all instruments running and exclaimed over the beauty of the display. On Mt. Haleakala, Maui, Mel Duran, J-10, said that data was recorded for 35 minutes by his team of Al Beldring and Bobby Borrego, both J-10, and Doug Dunbar, Charles Lewis, Don Wright, and Bob Salas, all of EG&G. At the Barnyard optical station near the Kauai launch site, Gordon Smith, J-10, and his group of Casey Stevens, J-10, and Stan Gamsby, Jack Jekowski, Pete Olivas, Pete Zavattaro, George Hughes, and Herb Holmes, all EG&G, were able to acquire 50 minutes of valuable optical records until the brightening sky of sunrise ended the display.

Others who participated in the May experiments in Hawaii were: Anne Phillips, J-16, who designed computer programs for the Waso experiment; John F. Pacheco, SP-2, property management and logistics; Allan Theobald, University of Southampton, VLF measurements; Bob Dinger, Naval Research Laboratory, geomagnetic micropulsation measurements; and Walter Chesnut, Stanford Research Institute, striation formation phenomena.

Preliminary data analysis showed the ions to be moving about 50 per cent faster along the field lines than classical physics calculations predicted. According to Pongratz, the Loxia experiment allowed scientists to use the earth's magnetic field as a magnetic bottle to study some of the plasma-physics problems en-

At last—"Loxia does her gaudy thing!" Ionized barium particles follow a geomagnetic field line and stream to the south just a few seconds after a shaped charge was detonated around a cone of barium metal. The explosion vaporized the barium and directed the vapor stream at a large angle away from the earth's magnetic lines. When the barium particles became ionized from the ultraviolet radiation of the sun they were turned from their original direction by magnetic attraction of the field. The round glob of material around the detonation point is composed of neutral barium and explosion debris. Loxia yielded data that will keep researchers busy for years.

countered on a much smaller scale in controlled thermonuclear research (CTR). The experiment was designed to produce an unstable condition of the barium plasma in terms of direction of motion of the charged particles relative to a magnetic field. This condition would resemble that of the deuterium plasmas in some CTR fusion machines. Unstable plasmas with ions moving nearly perpendicular to the field and faster than those moving parallel to it may lead to the growth of electromagnetic waves to the point where they modify the ion trajectories. This may result in "pitch angle scattering," or leakage from the magnetic bottle. In the Loxia experiment, the bottle was the earth's surrounding blanket of magnetic field lines.

J-10's scientific advisors for the Loxia experiment, Group Leader Milt Peek and his alternate, Bob Jeffries, both veterans of pioneering barium injection experiments dating back to 1970, said that the wealth of data will keep analysts busy for years. This year promises to be one of the most fruitful in the LASL ionospheric study program.

The researchers hope that the successful injections of barium plasma into the magnetospheric polar cleft region in January (see Tordo Chronicles, Jan.-Feb. Atom) and the most recent success in Hawaii will be followed by another Arctic success similar to Tordo.

Plans are now being firmed up to carry out a probe of the polar cleft region with 2 rocket payloads launched from Cape Parry in Canada's Northwest Territories. As is frequently the case in research, the extremely successful Tordo experiment last January raised more questions than it answered about the polar cleft region. A new experiment called Project Periquito will be carried out in late November and early December by LASL and the Canadian National Research Council. A full array of observation stations, both ground and airborne, will be manned. Unlike the Loxia experiment which depended only on ground observations, Periquito will be observed from ERDA/Air Force NC-135 flying laboratories. The airborne optical stations will allow the experiment to be carried on even though the bad weather conditions typical of the Arctic winter prevent some of the ground stations from observing the event.

Art Beaumont, CMB-11, examines a replica of the heat source, held in his right hand, and a metal outer tube in which real fuel will be placed, held in his left hand. The fuel will provide power for 10 years.

Heart Power

Someday, perhaps as soon as in the mid-1980's, surgeons may be able to replace hopelessly damaged hearts in fairly simple and routine operations. Unlike the heavily publicized heart transplants of recent years, the new hearts should not be subject to rejection by antibodies generated in the patient's bodies. Instead, they'll be mechanisms as marvelous as any portrayed in a science-fiction way on the "Six Million Dollar Man" TV show. They won't be rejected because instead of consisting of living, "alien" tissue, the artificial hearts will be encased in inert plastics and metals that are acceptable indefinitely to human tissue. They'll be designed to function with reliability and virtually no attention by the patient for at least 10 years. At that time, the mechanism could be replaced in another operation.

If this vision becomes reality, the Los Alamos Scientific Laboratory will have made an important contribution. In 1967 LASL was named to develop the power supply for the artificial heart. The program was assigned to Group CMB-11 with Larry Mullins, CMB-11, and Glen Waterbury, CMB-1, as the principal investigators.

The entire program is supported by the U.S. Energy Research and Development Administration (it originated under ERDA's predecessor, the Atomic Energy Commission), and is coordinated with the National Heart and Lung Institute. The design and manufacture of the heart mechanism are by Westinghouse Corporation. The University of Utah, with its unique Division of Artificial Organs at its medical school, is responsible for bioengineering studies and will also conduct animal experiments. The animals chosen are calves of about 200 pounds weight to approximate the body mass of man. The first completely internal animal implantation is scheduled for this summer, although implants using early "bench models" of the mechanism, with portions of the apparatus mounted externally, have already been made in animals.

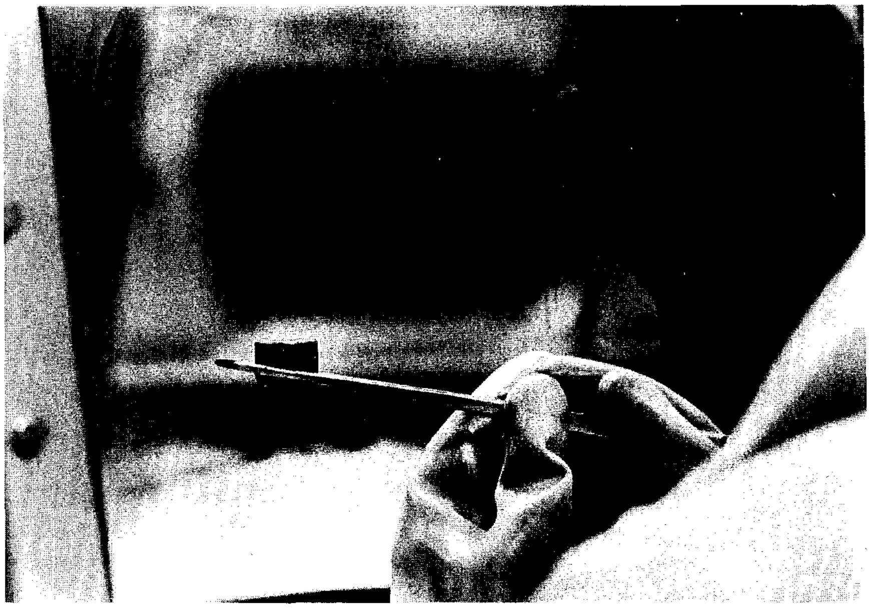
The total system for an artificial heart consists of 3 parts: the heart-pump itself, the engine which converts heat to mechanical energy to drive the pump, and the heat source.

The heart-pump is about the size of a small grapefruit and is shaped like a stubby capsule with rounded ends. These rounded ends house diaphragms which are actuated by various gears and levers in the center of the pump and which simulate the contraction-expansion pumping action of a natural heart. Interestingly, the design shows but 2 chambers whereas there are 4 in a natural heart. However, each chamber performs the function of 2 of the natural heart's chambers, and the circulation of blood in the body's 2 systems—one for the lungs, the other for the rest of the body—will be normal.

The heart-pump receives its power from a flexible cable, like a speedometer cable, which is connected to a Sterling-cycle engine. The engine, along with the heat source, is contained in a case about the size and shape of a small hair dryer. It is essentially a reciprocating engine driven by the expansion of krypton or argon gas, and was chosen for its reliability and excellent efficiency in converting heat to mechanical energy. About 20 per cent of the 25 watts of power produced by the fuel cell will be used to drive the heart-pump.

The fuel capsule, about the size of a "C" flashlight battery, is in close proximity to the cylinder head of the engine so as to provide heat for the expansion of gas. A nuclear fuel was specified to meet the device's requirement for a compact, very long-lasting energy

Above, Robert Dye, CMB-11, removes a fuel source from a press which has applied 20 tons per square inch of pressure to a mix of plutonium dioxide fuel and a binder. The fuel source is then fired in a furnace to form a tough ceramic solid. After firing, below, the fuel source is placed in a container; this one will be sent to Battelle Pacific Northwest Laboratory for radiation measurements.



source with minimal decline in power production and 100 per cent reliability. No nonnuclear source offered these advantages.

When implanted in a patient, the artificial heart-pump would replace the damaged heart, but the fuel container-engine package, linked to the heart-pump by a flexible cable, would be placed in the more-than-adequate "surplus" space available in the lower abdomen.

One of the more startling processes involved, at first glance, is the dissipation of excess heat into the patient's body without damage to tissue. The temperature of the nuclear fuel is over 800° C in the center of the fuel—more than enough to melt lead and obviously far higher than living tissue could tolerate. Ingenious thermodynamic engineering makes the apparently formidable problem no problem at all. A liner containing vacuum cups surrounds the fuel, insulating it and resulting in a temperature very close to that of the body from the little heat that reaches the outer surface of the container. Some of the heat is converted to usable mechanical energy. But a great deal of it is removed in a cooling system like that of an automobile engine.

Coolant surrounds the cylinder head of the Sterling-cycle engine and is pumped through lines enclosed in the insulated casing for the flexible shaft leading to the heart pump. There it is circulated through passages in the pumping chambers where the flow of blood through the heart-pump cools it. At no point will the coolant exceed stringent standards of temperature and heat flow established to prevent damage to tissue or blood.

Startling, too, at least to the layman, was the nuclear fuel selected from among several likely candidates: plutonium-238. With its half-life of 87 years, it can easily provide energy for 10 years or more. For better or worse, plutonium conjures up images of deadly radioactivity, and it may take the public some getting used to to accept the fact that plutonium in the proper form is, in fact, the safest material for this type of application.

There is no denying that as small particles, which could be ingested, plutonium is a hazardous material to be handled with every safeguard. But plutonium of very high purity, in appropriate ceramic form, is not only relatively safe and easy to handle, but in the artificial-heart fuel cell, entails radiation exposure so minimal, even for periods of 10, 20, or more years, that it constitutes acceptable body doses.

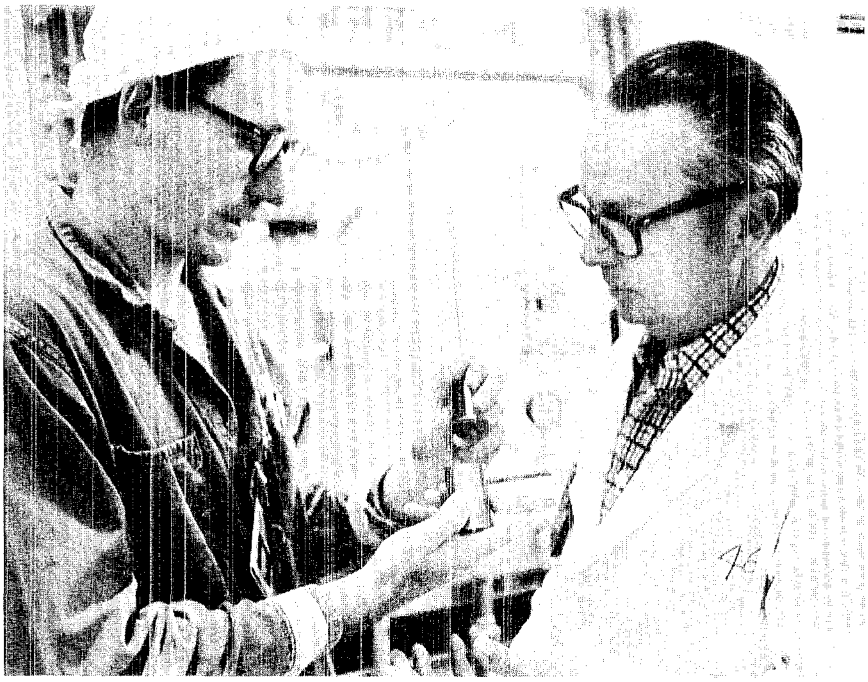
The compound used in the fuel cell is plutonium-238 dioxide, and the radiations of greatest interest are alpha particles, neutrons, and gamma rays. Alpha particles are readily stopped and form harmless helium. Neutrons are less readily stopped, but neutron production is minimized by the exceptional purity of the fuel. The gamma rays are of such low energy that most of them are stopped by metallic shielding 15/1000 of an inch thick.

Although the amounts of helium produced are minute, they must, nevertheless, be vented from the fuel cell. A trap and a vent, with an inside diameter no larger than a human hair, serve this purpose. The very small amount of helium released can be absorbed easily and disposed of by the body.

The trap serves another purpose. In addition to helium, extremely small quantities of radon, a radioactive gas, are also produced. Fortunately, radon decays to lead in a matter of seconds. Any radon generated is kept in the trap more than long enough for it to change to lead. The lead remains in the trap rather than being discharged into the body.

The area of greatest concern in safety is not so much the fuel substance or the mechanism itself, but in what could happen in the event of an accident to a person in whom a fuel container has been implanted. Mullins explains that fuel container design, at the present stage, takes various accidents and mishaps into account. For instance, the container has been constructed of high-strength alloys of refractory metals to resist impact, and of precious metals, such as platinum, to resist oxidation. Some incineration tests have been made. "At this stage," Mullins adds, "we're more concerned with designs for safe laboratory tests and animal implantations. As we move closer to models for human implants, we'll shift our emphasis to making proven models indestructible in the face of any credible accident we can imagine, including rifle bullets and castastrophic fires."

A facet of the program presently receiving emphasis is the development of fuel processing procedures which are both more economical and safer than those in present use, while still producing fuel of very high chemical purity. On a laboratory scale (only 3 implantable fuel cells have been built to date, with 6 more scheduled for the present fiscal year), economical processing is not of major concern. But with an estimated production rate of some 50,000 fuel cells per year projected once a total artificial heart system is introduced, production economy becomes a major factor. "For this reason, we will probably not use iridium in the casing, although its corrosion resistance is superb. It is extremely expensive, and there just wouldn't be enough of it available for volume production," Mullins says.



Charles Foxx and Larry Mullins, both CMB-11, inspect an experimental container with a trap and vent system for controlling helium and radon generated by the fuel. This system has been tested for 6,000 hours in the sealed "laboratory" behind Foxx and Mullins.

How will the artificial heart actually work in humans? Judging by reports from other participating institutions, the outlook is encouraging. Those involved in bioengineering are confident that within reason and barring extreme exertions, the patient will live a normal life. The rate of flow of the blood stream will be regulated by the body's mechanism for dilating or constricting blood vessels to accommodate to periods of rest or mild exertion. The artificial heart, unlike a human heart, will pump at a constant rate. On the other hand, a more sophisticated system of the future might include a tiny computer with sensors connected to appropriate body systems to change pumping speed.

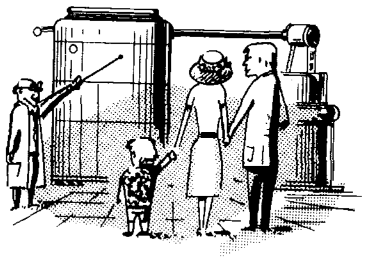
The development of the heat source for the artificial heart is a superb example of the value of spinoff at LASL, as a wealth of technical knowhow in plutonium processing is applied to the project. Provision is being made in the new plutonium facility under construction at TA-55 for processing medical-grade plutonium. The technology now being developed for this will surely find application in other plutonium processes.

And the project is an excellent example of LASL interdisciplinary research and development, drawing on specialized skills in metallurgy, nuclear chemistry, and ceramics, to name a few.

Even as pacemakers, which provide mild electric stimuli to natural hearts, have become commonplace today, so complete artificial-heart systems may become commonplace tomorrow—utterly reliable mechanisms pumping without falter day and night for 10 years or more, moving more than 5 million gallons of blood in the process with power supplied by a small amount of nuclear fuel that will have generated over 2,000 kilowatt-hours of energy.

And LASL's contribution would be there—at the very heart of things.

10 years ago in los alamos



Culled from the July and August, 1965, files of The Atom and the Los Alamos Monitor by Robert Y. Porton

Open to Public:
The LASL Main Library, one of the largest and most complete technical reference centers in the nation, will become a "public" library on July 6. The action is one of the Laboratory's moves to extend use of its facilities to other qualified researchers.

Appointment:
W-Division leader Harold Agnew is the new chairman of the U.S. Army Combat Development Command (CDC) Scientific Advisory Group. He was appointed by Lieut. General Dwight E. Beach, commanding officer of the CDC.

No Sale:
The AEC reaffirmed its previously stated position that it does not intend to offer the 243 remaining Denver Steel houses for sale under the community transfer program. The announcement said these units could not be brought up to acceptable FHA standards without an exhorbitant amount of remodeling and they are long past their life span. It is now planned to keep them as governmental rental units until they can be replaced by private housing construction, and then to tear them down. The Laboratory allocation includes 85 of the units, and there are rarely any vacancies.

Family Days:
A resounding success! That's the official verdict on Los Alamos Family Days 1965. The two-day event left denizens of the Hill with aching feet and somewhat taxed composures—but with increased understanding of what makes the Atomic City tick. An estimated 20,000 persons took advantage of lowered security barriers to flock to the Laboratory.

Pu Patent:
Two former LASL staff members, one of them now dead, are among three scientists who have been awarded a patent for the process that yields the man-made element, plutonium. The patent was granted to Arthur C. Wahl of Washington University, St. Louis, Mo., and the late Joseph W. Kennedy. Kennedy was head of the old CM Division from 1943 to 1945. He died in 1957. Wahl was at Los Alamos from 1943 to 1946, and was a group leader in CM Division.

Double Header

REUNION AND BICENTENNIAL CELEBRATION

The 30-year anniversary reunion of Los Alamos veterans and pioneers had an extra meaning for some 800 attendees when it was held June 20-22. With Los Alamos being a historic as well as scientific community, the weekend was highlighted by the official designation of Los Alamos as a Bicentennial Community.

Participants poured into Los Alamos all day Friday, June 20, registered at Fuller Lodge, and mingled in an informal party by Ashley Pond during the evening hours. During daylight hours on Saturday, attendees watched vintage World War II movies and slides, took bus tours, and visited the Bradbury Hall of Science.

Saturday night's barbecue and program featured presentations to the Los Alamos Bicentennial Commission of a Bicentennial flag by Willard Lewis, special assistant to the Secretary for the Southwest Region, U. S. Department of the Interior, and of a Bicentennial certificate by Shirley Abbott, regional director of the American Revolution Bicentennial Administration. A U.S. flag was presented by U.S. Representative Manuel Lujan, and New Mexico Lieutenant Governor Robert Ferguson, Director Harcld Agnew, and Raemer Schreiber, deputy director retired, were speakers. Later entertainment included music by a reunited World War II "combo," Ed Macmann and the Keynotes.

Before departing Sunday, many of the attendees took time to thank reunion cochairmen Jacob Wechsler, WX-DO, and Alvin Van Vessem, WX-7, for a job well done.